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# PATENT SPECIFICATION

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COMPLETE SPECIFICATION

## Excavating Apparatus

I, ALBERT DE SMAELE, a Belgian Subject, of 17 Place George Brugmann, Ixelles, Brussels, Belgium, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with an excavator apparatus for carrying out drilling in rocks, soil coal seams, mineral and solid substances of all type, and more particularly to a remote controlled apparatus which, by a convenient interconnection of its control members and members the movement of which depends on the position of the apparatus in the ground, can be made to operate automatically therein, according to any predetermined programme.

According to the present invention there is provided excavating apparatus for making boreholes in rocks, soil, coal seams, minerals and solid matter of every nature comprising at least one excavating tool, a motor for driving said tool, means for continuously removing the excavated materials, members serving to effect displacement of the apparatus together with means for altering the direction of movement of the apparatus, means sensitive to variations in working conditions of the tool in space and time and adapted to generate signals in response to such variation, a flexible bundle of lines and conduits serving to connect the excavating apparatus to a remote control position and a hollow elastically deformable fitting disposed around one of the constituent parts of the excavating apparatus and adapted upon expansion by the introduction of a fluid under pressure to make contact with the internal surface of a borehole being made by the tool whereby to prevent the passage of any liquid or gas in the borehole from one side of the fitting to the other.

Preferably the excavating tool works in a fluid tight working chamber defined in front by the cutting face, on the sides by the walls of the dug passage, and to the rear by the said fitting disposed around the apparatus. The continuous evacuation of the excavated materials may be effected by the continuous passage of a suitable fluid under pressure into and out of the said fluid tight working chamber which serves to entrain the excavated material and carry it away. Suitable fluids are compressed air, nitrogen, water or a dense suspension as used in the flotation process, that is to say a suspension of a suitable material e.g. clay in a suitable liquid carrier e.g. water, of which the specific gravity is greater than unity.

The progress of the apparatus through the soil may be by a reptile-like motion according to a known principle, the applications of which are already known in various mining apparatus. A preferred form of apparatus according to the invention is distinguished in this respect, from known apparatus, by the manner of anchoring in the soil the two elements the alternate bringing nearer and spreading apart of which brings about the reptile-like movement.

According to the invention, each of these two elements carries at least one, and preferably two, pneumatic or hydraulic tyres which can be inflated and deflated selectively, individually, respectively in pairs.

These tyres, which thus play the part of devices clinging to the soil, serve at the same time to take up the various reactions produced by the movements of the excavating tool, and one of them at least provides the airtight fitting which closes the excavating chamber at the rear.

The steering of the apparatus in the soil is provided for in various ways. In one of them, the apparatus carries means comprising at least one expansible elastic casing, or tyre band, the outer facing of which rests against the wall of the borehole and which is arranged to be deformed by introducing into this (or these) casing(s), a fluid under pressure. It may for instance be achieved by subdivided air chambers contained by a suitable arrangement within one or more of the said tyres

[*Price 3s. 0d.*]

and serving for the movement of the assembly.

In another form of steering gear apparatus, the apparatus comprises several frames of which at least one is articulated to another, the relative displacement of these frames being ensured by an orientating device, e.g. a coupling.

The invention also provides an entire assembly of control and signalling members, some of which are mounted at the remote control position whilst the others are mounted on the apparatus itself, the connection between these two groups being established by the flexible bundle of electric, pneumatic and/or hydraulic conduit previously mentioned, certain members (valves, relays or others) may if desired be included along said flexible bundle, and are preferably located in supports for this bundle, which travel with it.

Other details of the invention will become evident from the description which follows, given by way of example only, of one preferred embodiment of the invention explained with reference to the diagrammatic drawings accompanying the present specification. In these drawings,

Figure 1 represents in perspective a general exterior view of one form of apparatus according to the invention.

Figure 2 is a similar general view of another apparatus according to the invention.

Figure 3 is a partial longitudinal section of the apparatus according to figures 1 or 2.

Figure 4 is a transverse section along the line IV—IV of figure 1.

Figure 5 is a detail of the control device of the apparatus according to figure 2.

Figure 6 is a detail of the device according to figure 5.

Figure 7 is a longitudinal view of a variant of the cutting member shown in figures 1 and 2.

Figure 8 is a transverse section along line VIII—VIII of figure 7.

Figure 9 is a detail of a section of the device shown in figure 7.

Figure 10 represents a drift correcting device.

Figure 11 is a view of an intermediate support.

Referring first to figure 1, an excavating tool 4 driven by a motor housed in a casing 3 is shown. In the present example, this is an electric motor, but it is apparent that it may be replaced by a compressed air motor or by an hydraulic motor. The casing 3 which for the convenience of the description can be considered as a tool holder support, is connected by a structure 2 (tubular in this case) which is slidably mounted in another concentric structure 1 (in this case, tubular). Pneumatic tyres, 1*a*, 1*b*, fitted to the outside structure 1, and pneumatic tyres 2*a*, 2*b*, fitted to the interior structure 2, enable these elements to grip the soil as will later be discussed. At the rear end of the apparatus can be seen a flexible bundle of various conduits which the apparatus trails behind it during the course of its progress through the soil, such bundle comprising a spoils evacuation tube 8, a compressed air conduit 9, and a bundle of electric cables 10 serving as the connection between the control members placed at a remote position and operating means such as motors and other analogous devices, as well as the transmission of signals revealing to the remote position the situation and the progress of the apparatus during its travel through the soil.

The excavating tool comprises cutting members 4*a* (Figs 1, 2, 5). The cutters 4*a* are carried by a disc 4 mounted on a rotor enclosed in the housing 3 and driven by the motor contained in said housing. The spoils pass through openings 4*b* of this disc into a chamber contained in the housing 3 and from there into the tube 8 from which they are evacuated from outside the borehole. The compressed air arriving by conduit 9 and passing into the excavation chamber through apertures 4*c* provided in the bevelled edge of the disc serves as vehicle for these excavated materials.

In the device of figure 7, two sets of cutters are mounted on a rotor 22 driven by the motor. One set comprises fixed cutters 25 which are connected to the rotor by arms 26. A second set comprises cutters 20 carried by arms 21 articulated to the rotor by pivots 21*a*. An internal control system, a description of which will be given later, makes it possible to turn the arms 21 about these pivots and in consequence makes it possible to bring the cutters 20 from an operative position, away from the centre of the rotor, to a folded position nearer to the centre thus allowing the withdrawal of the machine from a borehole in which the diameter of the free passage has been reduced by the placing of revetments. In the case of the present embodiment (if desired also in others), the excavated materials are taken up by scoops 23 fitted to the arms 21 which turn with the rotor and which empty the excavated materials into a hopper 24 where they are led by the vehicle made up of compressed air, into the tube 8 capable of taking them along to a selected destination, relatively remote. The inlet to the hopper 24 is closed by a grill 24*a* which permits ingress only of fine excavated materials. The latter reach the tube 8 by a passage $24^1$. The larger material is rejected and drops to the bottom of the borehole again; occasionally, it remains caught against the grill and is then crushed by the scoops. By way of variation, the grill could be limited to a sector (S1, S2) and in that case the large pieces, at the end S2, will drop into the hopper and will be crushed between teeth carried by the rotor and the inner wall of the hopper as shown in Figure 8. The crushed material is removed by the tube 8.

The removal of the excavated materials by means of gas-pressure is made possible by the fact that the cutters operate in a narrow excavation chamber, limited in front by the ground itself, which is attacked by the tool, and to the rear by the apparatus itself; in the embodiment under examination the tyre 1*a* fixed to the external casing, produces an air-tight joint between the rocks and the said casing.

It is apparent that the compressed air used for removing the excavated materials can be replaced by another gas or by a liquid: e.g. nitrogen may well be used in boreholes where firedamp may be liberated. It is also advantageous to provide in the interior of the entire apparatus an excess pressure of gas so that dust may not penetrate and the possible ingress of water into the interior of the machine is opposed.

The mechanism which ensures the deployment and the withdrawal of the tool-carrying arms 21, by rotating about their pivots 21*a*, will now be described (see figure 9). Each arm has two part 21 and 21'. The outer parts 21 carry the cutting tools. The inner parts, 21', are articulated to a common control head 31. The latter is actuated by a rod 32 held in a screw-nut 33 cooperating with a screw 34 set on the shaft 35 driven by the motor. The screw-nut 33 and the rotor 22 cooperate through a system of grooves and channels 36, 36' which permit the sliding of the screw-nut in the rotor, but do not enable it to turn. On the other hand, all longitudinal displacement of the screw 34 is prevented. Abutments 37, 38, limit the longitudinal displacement of the screw-nut. It is only when the screw-nut comes into contact with these abutments that the rotation of the shaft 35 produces the positive drive of the rotor 22; one or other of the abutments will come into action, depending on the direction in which the shaft turns. It will be seen that when the shaft turns, the rotor tends to remain immobile through inertia and the screw-nut begins to move longitudinally, driving the head 31 and producing the spreading or the withdrawal of the arms 21. The end of the stroke of the screw-nut corresponds to the full spread or to the full withdrawal of the arms. Figure 9 shows the position of the mechanism when the arms are spread. To withdraw them it is necessary first to stop the motor, then to let it turn for a short while in the opposite direction to its normal rotation.

The progress of the apparatus is made by reptile-like movements obtained by the relative movement of the two slidably connected elements which, alternately, engage themselves in the soil surrounding the apparatus. It can be seen from figure 1 that one of the slidably connected elements is the interior casing 2 and the other is the outer casing 1 into which the casing 2 penetrates telescopically. To produce the relative movement of these two casings, the casing 2 is connected by a rod 6 to a piston 6*a* movable in a cylinder 7 housed in the casing 1. (It is of course understood that the cylinder could be fixed to the casing 2 and the piston to the casing 1). According to which side of the piston receives, by means of a distributing system of a known type and not shown here, the thrust of a fluid under pressure—by way of example, air—the relative movement of casing 1 and casing 2 is produced in one direction or the other. In order that there may be a reptile-like movement it is necessary to obtain alternating engagement of the elements, with the soil. For this purpose, the tyres are mounted on the faces connected respectively to one or other of the elements, and some of these tyres can be inflated at will, whilst the others can be deflated. The tyres 1*a* and 1*b*, are thus integral with the element 1, and the tyres 2*a* and 2*b* are integral with the element 2. These tyres, which are arranged in such a manner that two tyres of one casing have between them one tyre of the other casing, could also be arranged in another manner. Thus for example the tyres of one casing could be arranged consecutively. The supports of the rims of the tyres 2*a* and 2*b* are connected to the casing 2 by passing through slots 2°*a* and 2°*b* provided in the casing 1. To make the tool advance with respect to the casing 1, the tyres 1*a* and 1*b* which are connected with this casing are inflated and the compressed air is directed onto the left side of the piston 6*a* as is shown in figure 3. If on the contrary it is desired to restore the relative positions of the casing 1 and the tool in order to have it occupy a fresh starting position, the tyres 1*a* and 1*b* are deflated, and the tyres 2*a* and 2*b* inflated—which immobilizes the casing 2 with regard to the soil—and the compressed air is directed onto the right side of the piston 6*a*. By a suitable coordination of the deliveries of air feeding the tyres on the one hand and the faces of the piston 6*a* on the other hand, the reptile-like movement of the apparatus can be produced in an absolutely automatic manner. It will be sufficient therefor to control the respective deliveries by the action of members at the end of the stroke. Such a system is sufficiently clear in operation not to require a detailed description.

The steering of the apparatus in the substance through which it goes can be obtained in various ways.

A first method consists in producing a deformation in one (or in several) of the tyres. By means of a drop in pressure in one of them, for example, the apparatus will be caused to tilt under its own weight in the vertical plane. In this manner steering in the vertical plane only is obtained.

According to a more elaborate technique, one can, according to the invention, as is shown in figure 4, subdivide a pneumatic

body such as that shown into a plurality of sections—for example in three equal sections $1^{1}a$, $1^{11}a$, $1^{111}a$ (covered by a common covering $1^{0}$), the expansion and the contraction of which may be brought about separately by means of a distributor, suitably controlled, of a gaseous fluid or liquid, introduced into these elements. It will be seen that the action of the fluid in one of these elements can, by means of the local deformation of the latter, cause a deviation of the whole of the excavating apparatus with respect to the direction which it would follow if all its tyres were equally inflated or deflated. The same arrangement can be carried out on other tyres. It may exist, for example, on two tyres of a pair mounted on the same casing—for example on the tyres 1*a* and 1*b*. In this case, the angular disposition of the elements $1^{1}b$, $1^{11}b$, $1^{111}b$ (not shown) of the second tyre about the longitudinal axis of the apparatus may be identical to that of the elements $1^{1}a$, $1^{11}a$, $1^{111}a$ or alternatively the elements $1^{1}b$, $1^{11}b$, $1^{111}b$ may be rotated through 180° about the said longitudinal axis with respect to the elements $1^{1}a$, $1^{11}a$, $1^{111}a$ of the first tyre; the elements $1^{1}a$ and $1^{1}b$, $1^{11}a$ and $1^{11}b$, $1^{111}a$ and $1^{111}b$ are thus opposed with respect to the longitudinal axis. In both cases, a concerted deformation of the two similar elements, $1^{1}a$ and $1^{1}b$ for example, will produce a deviation of the whole apparatus, and by an appropriate choice of these elements, the apparatus can be directed at will. Asymmetry in the inflation of the tyres, which has the effect of redirecting the apparatus, is preferably introduced gradually, if desired in an automatic manner. The shape, the number and the distribution of the cooperating expansible elements such as those at $1^{1}a$, $1^{11}a$, $1^{111}a$, $1^{1}b$, $1^{11}b$, $1^{111}b$, can obviously be varied. It is therefore not necessary that these elements by their juxtaposition form complete tyres.

Another controlling device (figures 2, 5, 6, 10) comprises in the first place an articulation of the assembly of the tool-bearing support and of the interior casing 2, the axis of which is horizontal when the apparatus is placed in its normal operating position. The said articulation is made about the pivots 13, $13^{1}$ integral with the support 3 which carries the cutting disc or the cutting tools. These pivots are mounted in the arms 14, $14^{1}$ fixed to the casing 2. It will be noted that by the arrangement of two similar devices, one behind the other, at 90°, any direction, in space, can be given to the tool-bearing casing 3, the axis of casing 2 remaining in an unchanged position.

The device indicated at 5 in figure 2 actually consists of several parts, as shown in Fig. 6. One part indicated at 16 (Figs. 5 and 6) is movable with respect to the casing 2. Other parts constitute a coupling which establishes an optional connection between said movable part 16 and the tool-bearing support 3. The tool-bearing support or casing 3 has a toothed segment 15 which is capable of cooperating with a tooth 15*a* mounted on the intermediate casing 16 by a system of articulation shown in figure 6. In this figure, the numeral 16 followed by a letter indicates all the integral pieces of the intermediate casing, the whole of which has been shown diagrammatically by a rectangle 16.

The intermediate body 16 carries the arms $16^{1}$ which articulate about the pivots 13 and $13^{1}$. The tooth 15*a* is carried by an arm 17*a* of a parallelogram comprising also rods 17*b*, 17*c*. 16*a* and 16*b* are pivots fixed to the intermediate body. It is by means of the articulations $17^{1}c$ and $17^{11}c$, and said pivots 16*a* and 16*b* that the articulated assembly can become deformed. All the connecting rods of the parallelogram are in duplicate, the corresponding elements being parallel to each other and symmetrically disposed with respect to a vertical plane passing through the axis of the casing 2. It is thus only necessary to show one side of the assembly.

The rods 17*c* are attached to an armature 19 cooperating with the pole pieces 18*a*, 18*b* and 18*c* of an electromagnet the winding of which can be seen at $18^{1}a$. When the current passes through this winding, the armature 19 is attracted, the arms 17*c* pivot about 16*b*, causing the pivoting of the rods 17*a* and 17*b*. Hence, the tooth 15*a* approaches the segment 15 and tends to become engaged in a notch between the teeth thereof. It may however happen that the tooth 15*a* appears exactly opposite to one of the teeth of segment 15. To close the air gap as quickly as possible, the body 18*d* of the pole pieces of the magnet 18 is movable with respect to the body 16, in such a manner that if the armature 19 cannot approach the parts 18*a*, 18*b*, and 18*c* of the yoke because the tooth 15*a* is not opposite a notch between the teeth of the segment 15 the magnet tends to approach said armature by compressing the springs 18*e* which rest at the other end against the abutments 16*c* fixed to the intermediate body 16. The comparative force of the two springs will tend to engage the tooth 15*a* in a notch of the segment as soon as a slight displacement of the apparatus permits. The profile of the teeth 15 and 15*a* is designed to permit disengagement in the case where the pull of the earth exceeds a predetermined value.

The release is obtained by a return spring $17^{1}$ mounted between an abutment 16*d* of the body and a shoulder of the rod 17*b*.

Finally, the relative position in height of the tooth 15*a* and of the segment 15 is obtained as follows: the body 16 carries two forks 16*x* enclosing the pivots 19*a* of a screw-nut 19*b* through which an endless screw 19*c* passes. This screw, driven by a motor (not shown) is supported upon the extension arms 2*m* and 2*n* connected to the body 2. The

extension arms are resilient to permit the absorption of possible shocks. It is evident that hydraulic or pneumatic shock absorbers may be provided here.

Figure 10 shows a deviation correcting device. Only the elements cooperating with the two articulated bodies are shown here and those in a purely diagrammatic manner, that is to say, the journal pins 13, 13¹ connected here to the tool-bearing body 3 and chambers 13*a*, 13¹*a* connected here to the body 2 and intended to hold these journal pins. It can be seen that these chambers appear as cylinders in which the journal pins move in a piston-like manner. The injection into one or other of the chambers, of a fluid under pressure ensures the displacement of the corresponding journal pin and in consequence produces a movement, along the geometrical axis of the journal pins, of the tool-bearing body. The plane of orientation of the tool is thus displaced with respect to the axis of advance of the apparatus, which permits the correction of the deviation which the latter may have acquired during the course of its progress through the soil.

To cooperate in the air-tightness of the apparatus, there is provided, between the body 1 and the body 3, in front, and between the body 1 and the body 2, behind, bellows sleeves, shown in part at 30*a* and 30*b* in figure 2.

To permit the easy withdrawal of the apparatus, the tail-end 10*a* at the rear has an extension shaped as a snout which serves as a member for pushing away towards the walls of the borehole any obstructions which may hinder its backwards progress.

The apparatus also comprises signalling means which make it possible to indicate to the remote position all kinds of information which make it possible to follow the invisible tool's progress through the soil. Thus the information transmitted can include the amount of progress made through the soil by the apparatus in a given time, the angle existing at any time between the longitudinal axis of the tool-bearing body and the longitudinal axis of the principal body—this information gives the direction of the tool—the position of the apparatus with respect to the horizontal plane and with respect to a vertical plane of reference, the possible angle of rotation of the apparatus about its longitudinal axis, the state of inflation of the tyres, etc. . . . Most of the members which will be at the origin of the transmission of these details, such as a Selsyn control system, gyroscope, governor, compass, etc. . . . as well as impulse generators which produce the appropriate signals, are enclosed in a box accommodated in the apparatus. Another casing, provided on the outside, at the remote control positions, can contain the interconnecting devices of the control and signalling apparatus the setting into operation of which makes it possible to operate the apparatus absolutely automatically. It is obvious that the production of all or part of the control operations can be obtained from the remote position, by sending suitable impulses acting upon relays provided within the mobile apparatus, and to which one can thus give a mission which it will automatically accomplish according to a previously laid-down programme. These devices are of standard construction as regards remote control and therefore need not be described.

Figure 11 shows a longitudinal section of a form of support which can be placed at intervals along the bundle of cables and conduits which the apparatus drags along during the course of its progress through the soil. Such a support preferably comprises a spindle-shaped covering 40 comprising supporting plates, 39, 39¹ for the conduits and cables.

According to the invention, use is made of the presence of these supports to instal certain control apparatus (such as manometers) or steering apparatus (such as valves), 41 and 42, which it is normal to provide along any long-range transmission.

It is evident that many changes can be carried out in the arrangements described herein, without departing from the scope of the invention.

What I claim is:—

1. Excavating apparatus for making boreholes in rocks, soil, coal seams, minerals and solid masses of every nature comprising at least one excavating tool, a motor for driving said tool, means for continuously removing the excavated materials, members serving to effect displacement of the apparatus together with means for altering the direction of movement of the apparatus, means sensitive to variations in working conditions of the tool in space and time and adapted to generate signals in response to such variations, a flexible bundle of lines and conduits serving to connect the excavating apparatus to a remote control position and a hollow elastically deformable fitting disposed around one of the constituent parts of the excavating apparatus and adapted upon expansion by the introduction of a fluid under pressure to make contact with the internal surface of a borehole being made by the tool whereby to prevent the passage of any liquid or gas in the borehole from one side of the fitting to the other.

2. Apparatus according to claim 1 in which the said fitting lies intermediate the portion of the apparatus carrying the excavating tool and the end of the apparatus from which the said flexible bundle of lines and conduits extends so that the fitting when expanded against the wall of a borehole delimits a fluid tight working chamber for the tool bounded on the front and sides by the walls of the borehole.

3. Excavating apparatus according to claim

1 or 2 comprising two slidably connected elements, a system of pneumatic or hydraulic fittings or tyres carried by said elements, at least one such fitting or tyre being carried by each of said elements, the said fittings or tyres being capable of being individually inflated or deflated in such a manner as to create a frictional connection between one or the other of said elements and the soil or like material which surrounds them, means for alternately inflating or deflating the said fittings or tyres on each element, and a device carried by the apparatus adapted alternately to telescope and elongate the said two elements whereby displacement of the apparatus may be effected.

4. Excavating apparatus according to claim 3, in which the said slidably connected elements comprise two telescopically fitting elements around which the fittings or tyres are mounted.

5. Excavating apparatus according to claim 4, in which each of the elements carries two fittings or tyres so disposed that two fittings or tyres of one element have one fitting or tyre of the other element between them.

6. Excavating apparatus according to claim 4, in which each of the elements has two fittings or tyres so disposed that the two fittings or tyres of one element are followed by the two fittings or tyres of the other element.

7. Excavating apparatus according to any of the preceding claims in which said means for altering the direction of movement of the apparatus comprise at least one expansible elastic casing the outside of which bears against the wall of the borehole and which is deformable by introducing into it a fluid under pressure.

8. Apparatus according to claim 7, in which the said expansible elastic casing or casings are each formed with independent sections distributed around a circumference, each assembly of sections distributed around the circumference appearing externally substantially like a circular tyre around one part of the apparatus.

9. Apparatus according to claim 8, in which each sectional tyre has three sections of equal length.

10. Apparatus according to claim 8 or 9 including means allowing the state of expansion of one or more of said independent sections of a circumferential fitting and/or of another circumferential fitting of the apparatus to be selectively modified.

11. Excavating apparatus according to claim 3 and any of claims 7 to 10 in which the expansible casing or casings form part of said system of pneumatic or hydraulic fittings or tyres.

12. Apparatus as claimed in any of the preceding claims including one or more cutting tools mounted on arms connected to a rotor driven by the motor.

13. Apparatus as claimed in claim 12 in which the said arms are articulated on the rotor.

14. Excavating apparatus according to claim 13, in which each of the said arms comprises an external part carrying the cutting tools, and an internal part linked to a control head common to said arms, said head being connected to one of the elements of a nut and thread system, the other element of said system being connected to the control-shaft of the rotor, while abutments, fixed to the movable element of the said system, limit the stroke of the element in such a manner that the rotor is only positively driven by the shaft, in one or the other direction, when the said movable element of the nut and thread system has come into contact with one or the other of the said abutments, the possible stroke of the elements of the nut and thread system being selected to correspond to a complete spreading or to a complete withdrawal of the articulated arms with respect to the rotor.

15. Apparatus according to any of the preceding claims including scoops associated with the excavating tool and mounted on arms articulated on a rotor driven by the motor, and a hopper for receiving the excavated materials which are emptied from said scoops.

16. Excavating apparatus according to claim 15, in which the scoop-carrying arms carry cutting tools.

17. Excavating apparatus according to claim 15 or 16, in which one part at least of the hopper is outwardly limited by a wall enveloping part of the rotor, the said wall on the one hand and the rotor on the other hand being provided with roughened parts so that relative movement thereof serves to crush the excavated materials emptied into the hopper.

18. Apparatus according to any of claims 15 to 17 in which the scoops are adapted to crush larger particles of the excavated materials between parts thereof and grill elements which cover the hopper and prevent the said larger particles entering therein.

19. Apparatus according to claim 2 and any of claims 3 to 18 in which the said means for continuously removing the excavated material comprises a first flexible conduit connected to and in operation dragged along by the apparatus through which in operation a fluid under pressure is continuously fed into the said fluid tight working chamber, and a second flexible conduit similarly connected to the apparatus opening into the said fluid tight working chamber near to the said tool and serving in operation to carry away the excavated materials entrained in the fluid introduced under pressure through the said first conduit.

20. Excavating apparatus according to claim 19, in which the fluid so introduced is a compressed gas.

21. Excavating apparatus according to

20, in which the said gas is air.

22. Excavating apparatus according to claim 20, in which the said gas is nitrogen.

23. Excavating apparatus according to claim 19, in which the fluid so introduced is water.

24. Excavating apparatus according to claim 19, in which the fluid carrying away the excavated material is a dense suspension as used in the flotation process.

25. Apparatus according to any of the preceding claims including two slidably connected elements, one of the sliding elements being contained at least partially in the other, in which the casing of the motor which drives the said tool is articulated on the said inner sliding element by means of two opposed pivots integral with the said casing, the common axis of said pivots being perpendicular to the longitudinal axis of the machine, so that the said casing may assume, about the said perpendicular axis, various inclinations in relation to the said longitudinal axis of the machine, and including an assembly comprising a second element articulated about the same said perpendicular axis, a first part of a coupling, a second active part of the coupling being carried by said motor casing, and means for engaging and disengaging the parts of the said coupling, the said assembly being operatively connected with the inner sliding element by a screw and nut connection means being provided for producing a relative displacement of the said nut with respect to the said screw.

26. Apparatus according to claim 25, in which the said pivots terminate in two cylindrical chambers carried by the said inner sliding element, means being provided for injecting a fluid under pressure in one or the other of the said chambers, so that the fluid acts on the corresponding pivot as on a piston so as to displace the casing of the motor and hence the tool in relation to the inner sliding element of the apparatus, along the axis of the said articulation.

27. Excavating apparatus according to any of the preceding claims, in which the apparatus is made airtight and dust particles are excluded by flexible bellows and/or airtight joints between sliding elements.

28. Apparatus according to any of the preceding claims in which provision is made for creating an excess pressure in at least certain parts of the apparatus by means of a medium such as nitrogen, air or water whereby the penetration into the said parts of the apparatus from without of water, dust or gas is prevented.

29. Excavating apparatus for making boreholes in solid masses, substantially as described with reference to the accompanying drawings.

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FIG.1.

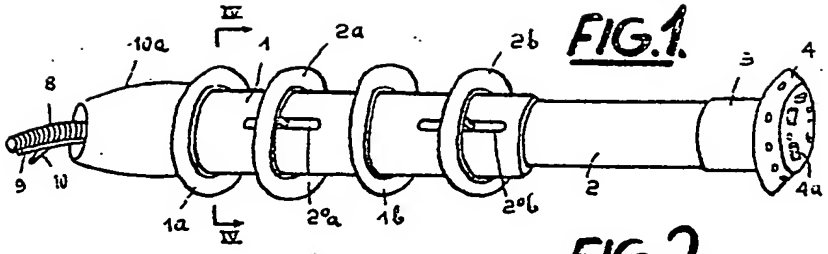



FIG.2.

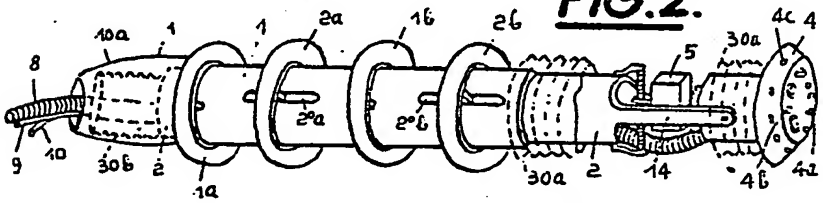



FIG.3.

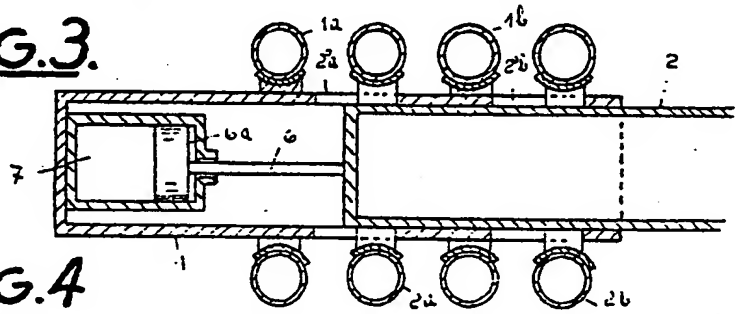



FIG.4

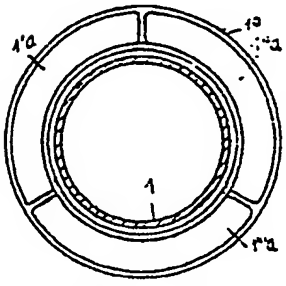



FIG.9.

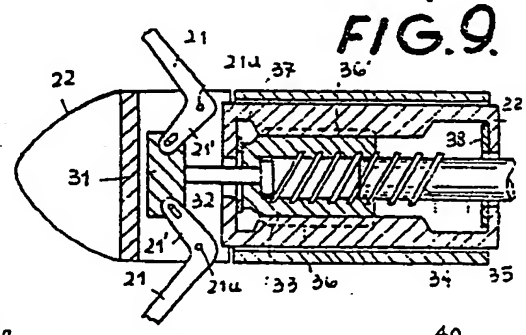
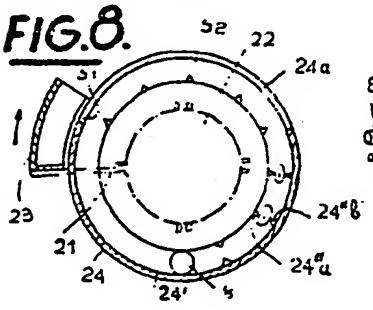



FIG.8.



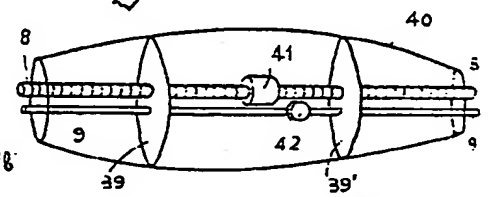




FIG.11.

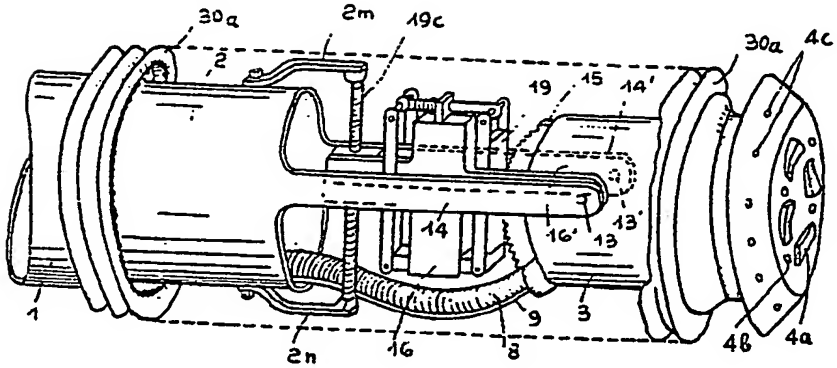
735,749 COMPLETE SPECIFICATION

2 SHEETS

*This drawing is a reproduction of the Original on a reduced scale.*

SHEETS 1 & 2

FIG. 5.





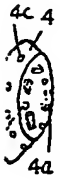



FIG. 6.

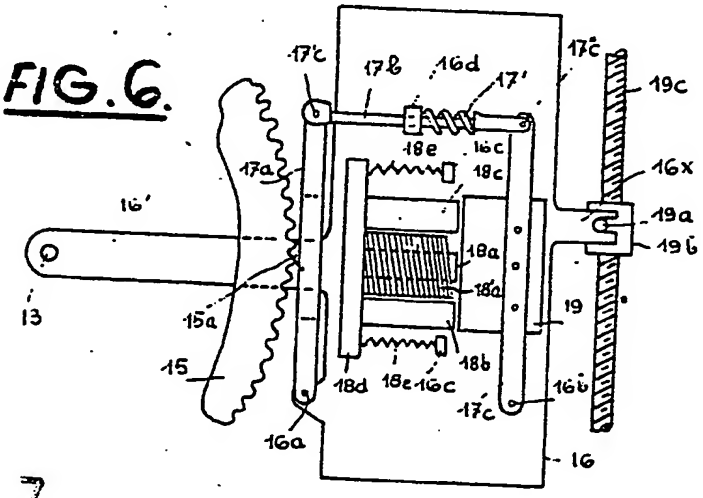



FIG. 7

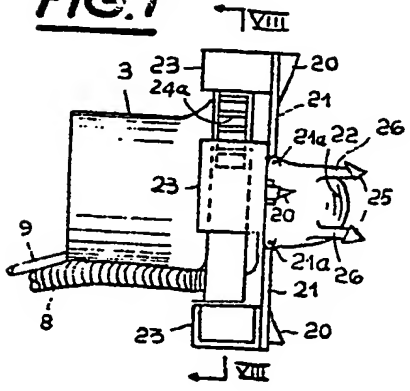
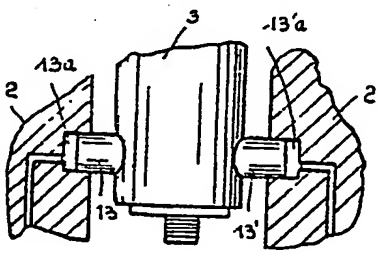



FIG. 10.





735,749 COMPLETE SPECIFICATION
2 SHEETS



FIG.1.

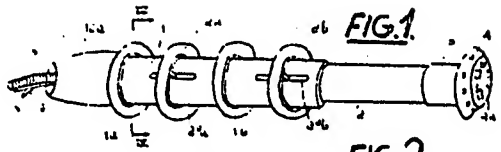


FIG.2.

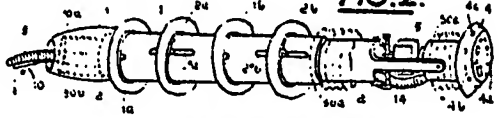


FIG.3.

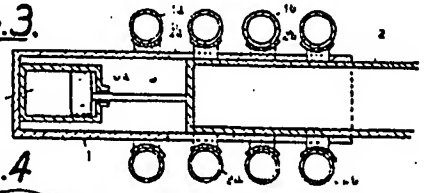


FIG.4.

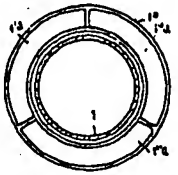


FIG.9.

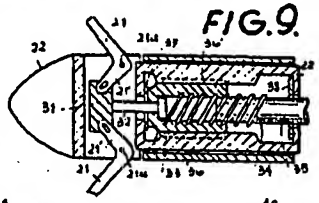
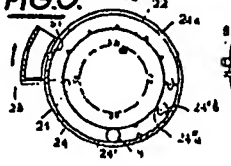


FIG.8.



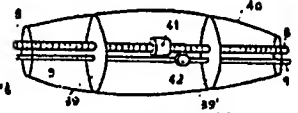


FIG.11.

FIG.5.

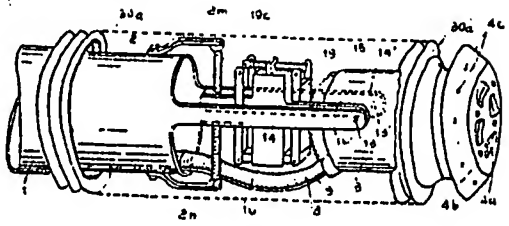


FIG.6.

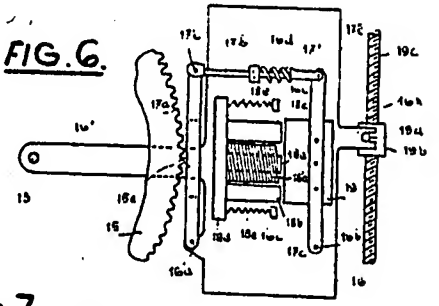


FIG.7

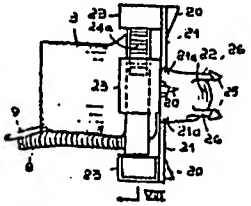


FIG.10.